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# **Fifth Annual Conference on Carbon Capture & Sequestration**

*Steps Toward Deployment*

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*Capture Technologies*

## **Intelligent Design of Solid Sorbents For Pre-Combustion CO<sub>2</sub> Capture**

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# Current CO<sub>2</sub> Capture Technology Systems Analysis Procedure

## Laboratory Scale



- 0.1 ft<sup>3</sup> Reactor Volume
- 0.27 scf per minute

Technically Possible?

Analysis

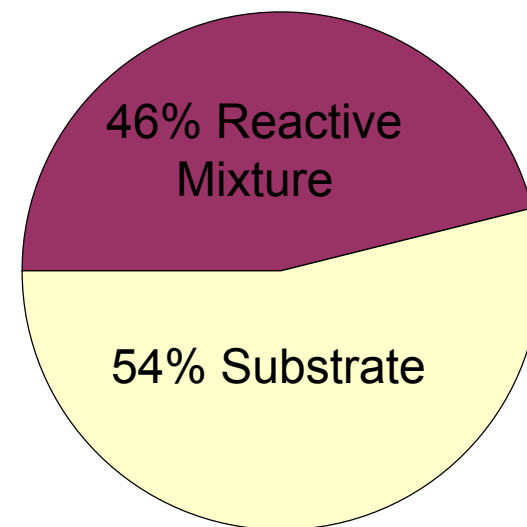
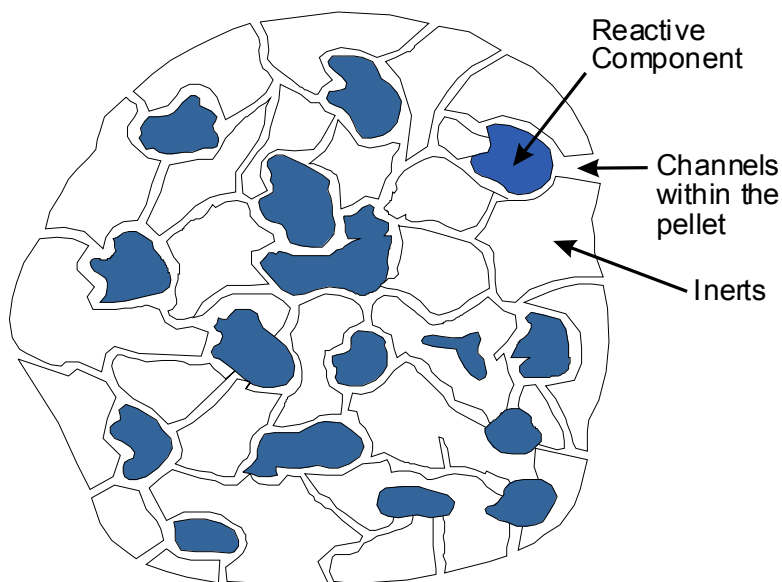
Economically Feasible?

## 400 MW Commercial Power Plant



- 57,000 ft<sup>3</sup> Reactor Volume
- 1,800,000 scf per minute

# High Pressure, Low Temperature Sorbent Systems Analysis\*

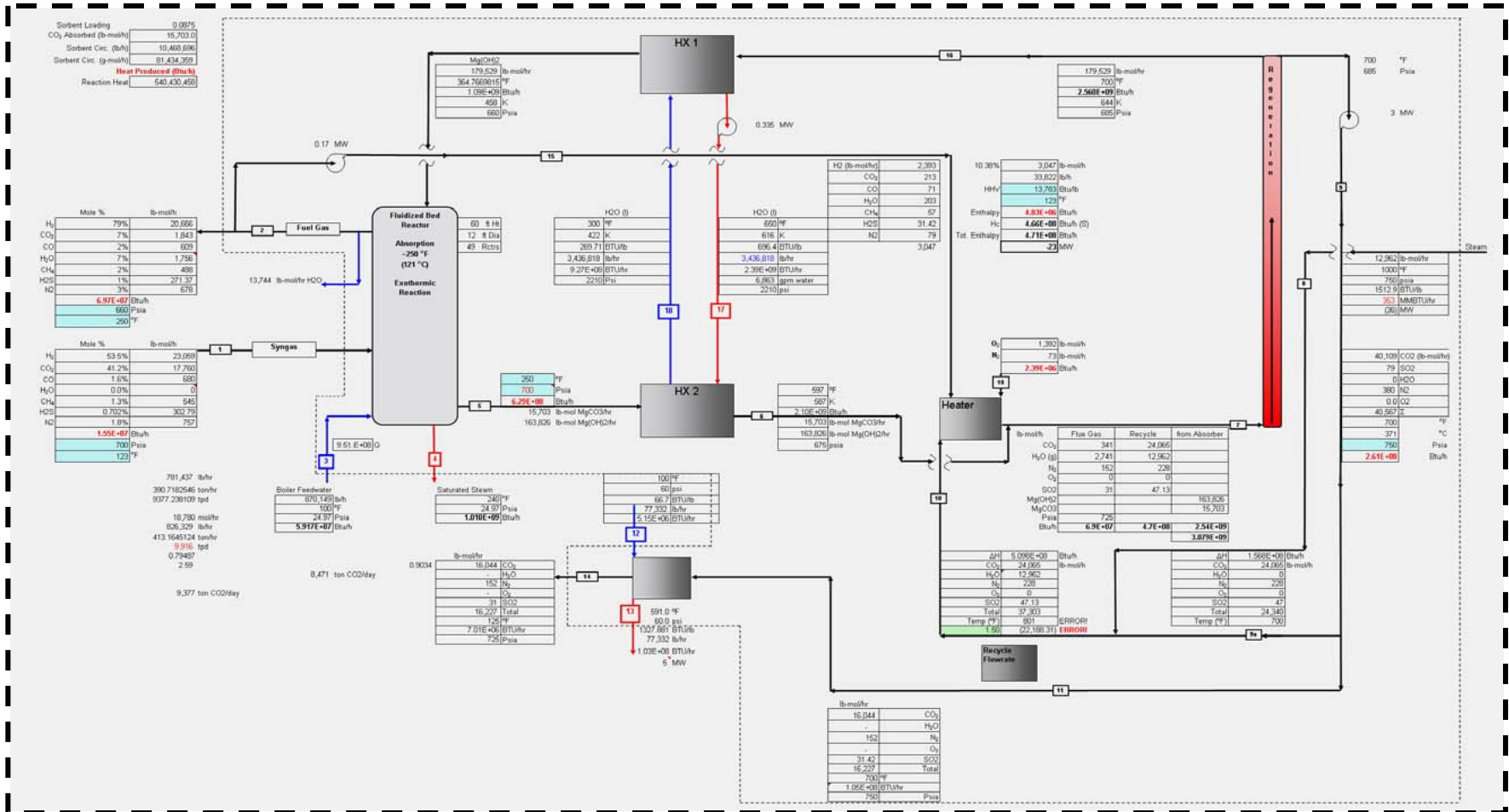


Capacity:  $>5$  g-mol  $\text{CO}_2$ /kg sorbent ( $>100\%$  increase over Selexol)

\*Sorbent development by Dr. Ranjani Siriwardane, NETL

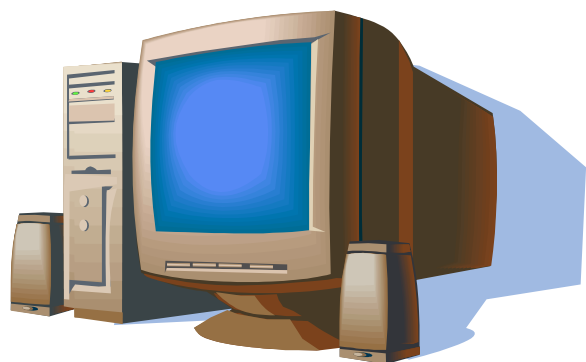


# Heat and Material Balance-Based Approach



# Preliminary Sorbent Development Analysis

## Systems Analysis Group



CO<sub>2</sub> Absorption Capacity  
Sorbent Cost



Makeup Rate  
Regeneration Requirements  
System Design

## R&D



Goal: Provide R&D with sorbent performance targets that will lower CO<sub>2</sub> removal system costs



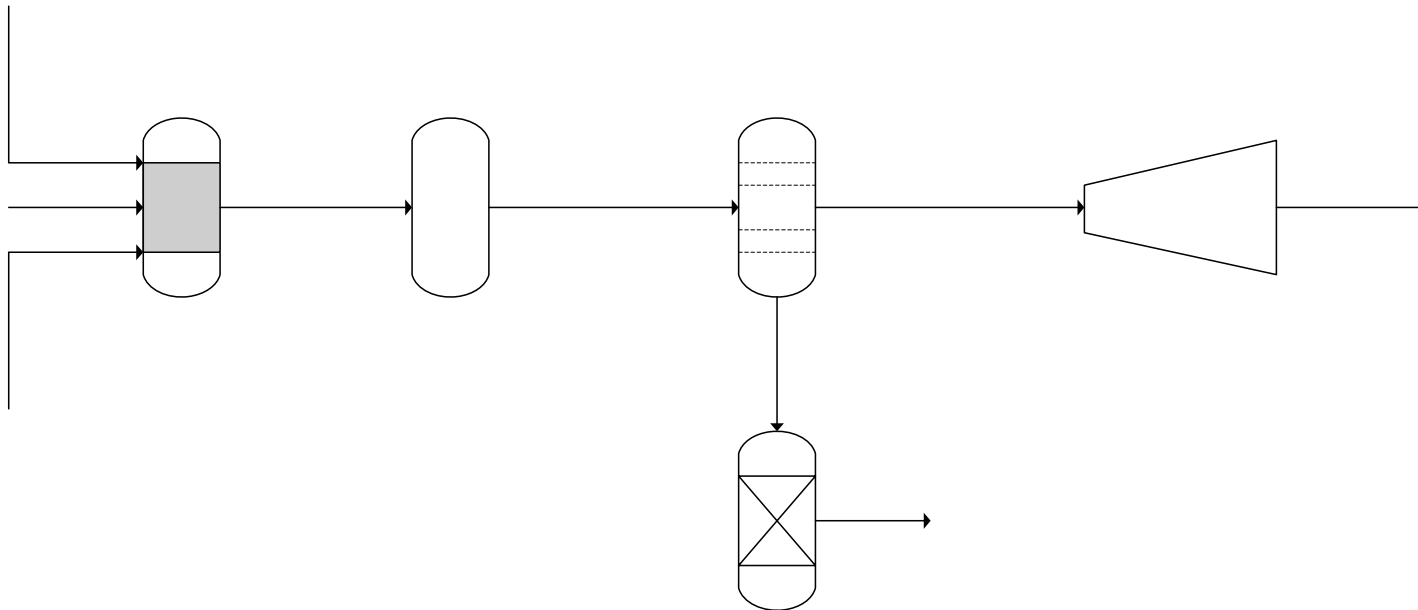
# IGCC Plant Investment

## Capital Expenses

| <u>IGCC Plant Capital</u> |
|---------------------------|
| Power Island              |
| Balance of Plant          |
| Gas Cleanup               |

## Operating Expenses

| <u>IGCC Operating Expenses</u> |
|--------------------------------|
| Capital Investment Fees        |
| Production Costs               |



# IGCC Plant Investment **with CO<sub>2</sub> Capture**

## Capital Expenses

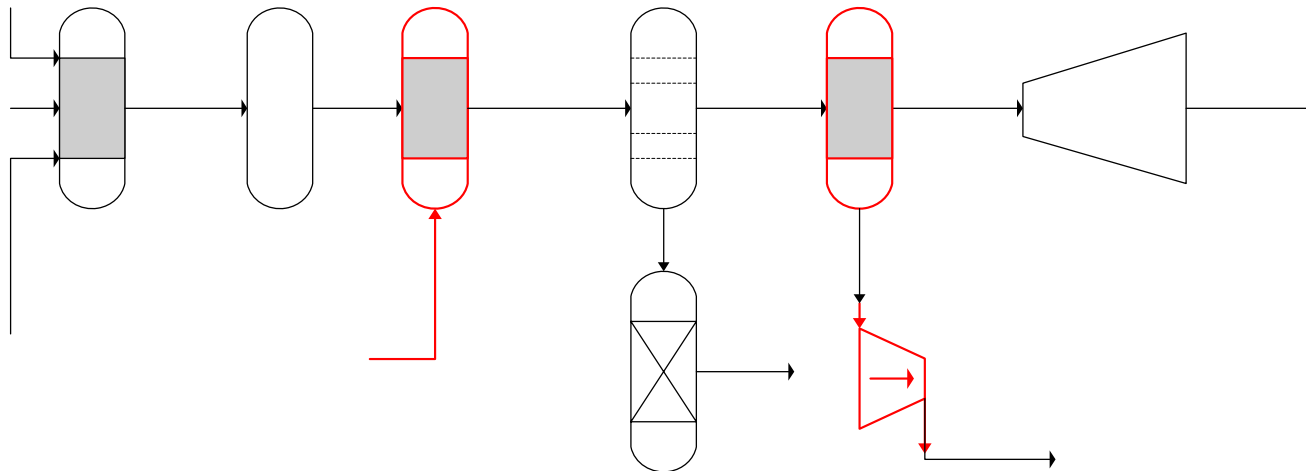
| IGCC Plant Capital             |
|--------------------------------|
| Power Island                   |
| Balance of Plant               |
| Gas Cleanup                    |
| -Water Gas Shift               |
| -CO <sub>2</sub> Removal       |
| -CO <sub>2</sub> Compression** |

\*\* Compression to 2200 psia

## Operating Expenses

| IGCC Operating Expenses |
|-------------------------|
| Capital Investment Fees |
| Production Costs        |
| -Fuel*                  |
| -Sorbent                |

\*Additional fuel required to make up for parasitic power loss





# IGCC with CO<sub>2</sub> Control

- **If we assume:**

- Free Sorbent
- No Sorbent Makeup
- Temperature Swing Regeneration  
(CO<sub>2</sub> Compression from 600 – 2,200 psia)

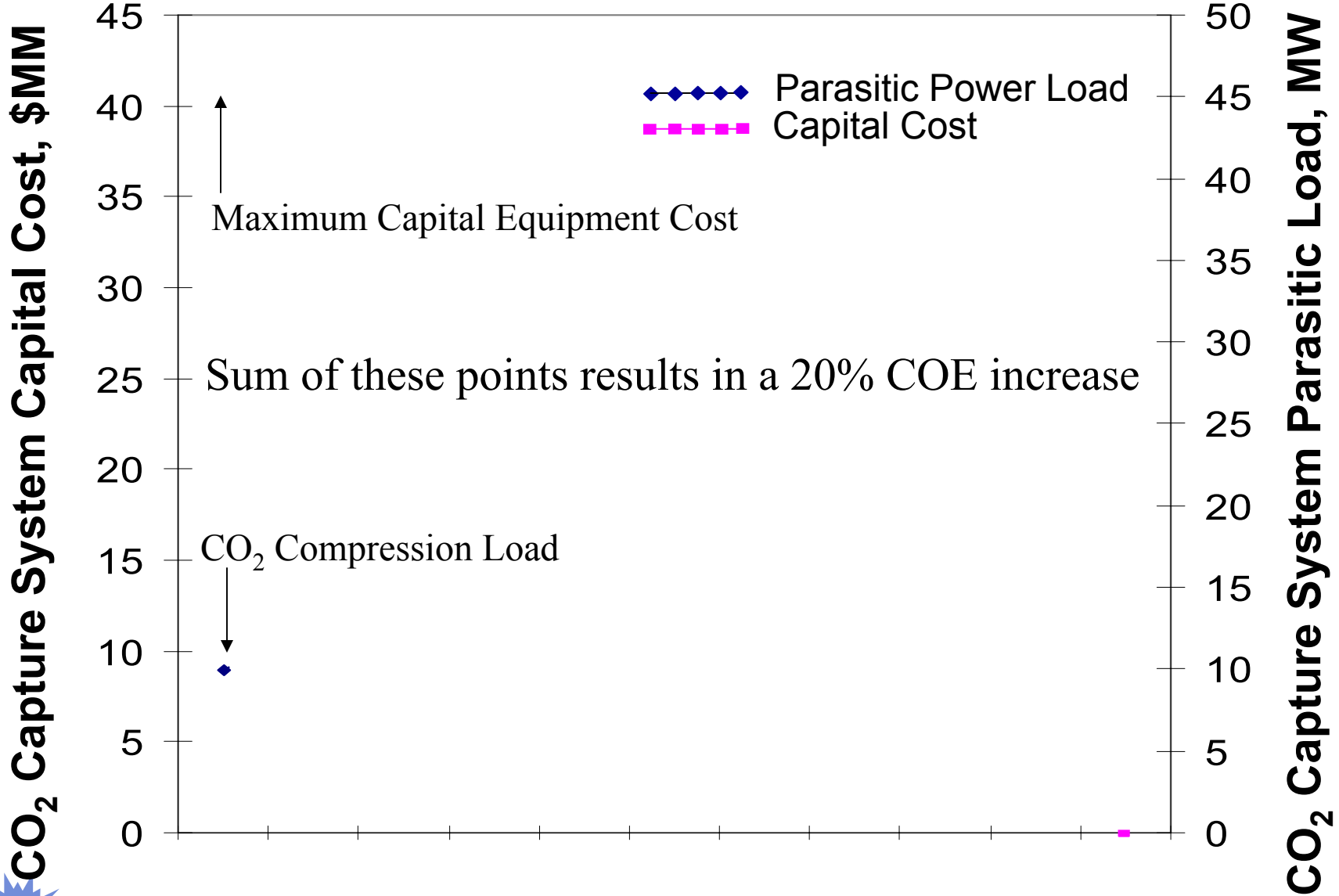
- **...and only consider:**

- Equipment Capital Cost
- Parasitic Power Load

**How much latitude do we  
have in achieving  $\leq 20\%$   
cost of electricity (COE) increase?**



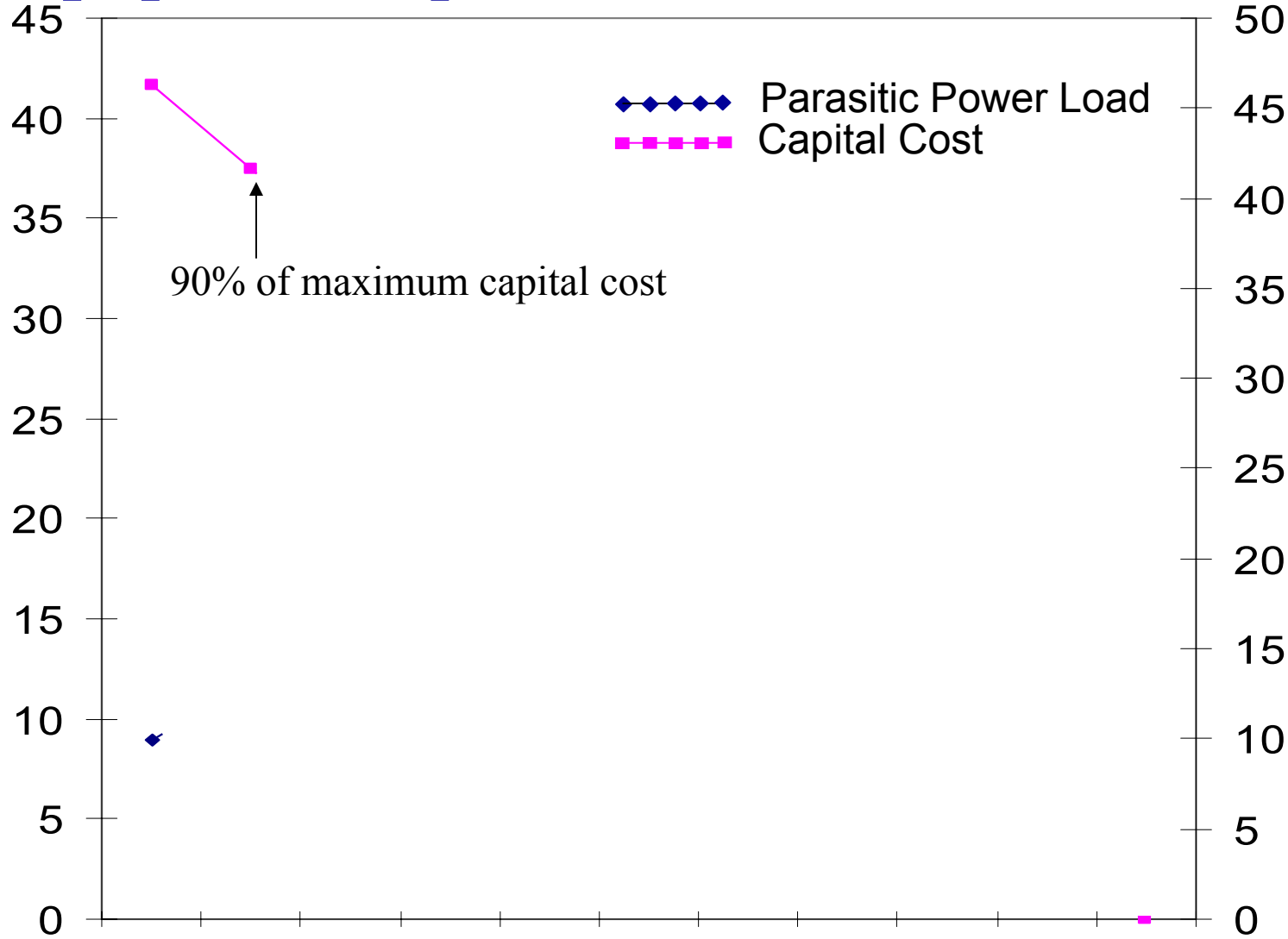
# Equipment Capital Cost and Parasitic Load



Basis: 400 MW (net) IGCC

# Equipment Capital Cost and Parasitic Load

CO<sub>2</sub> Capture System Capital Cost, \$MM



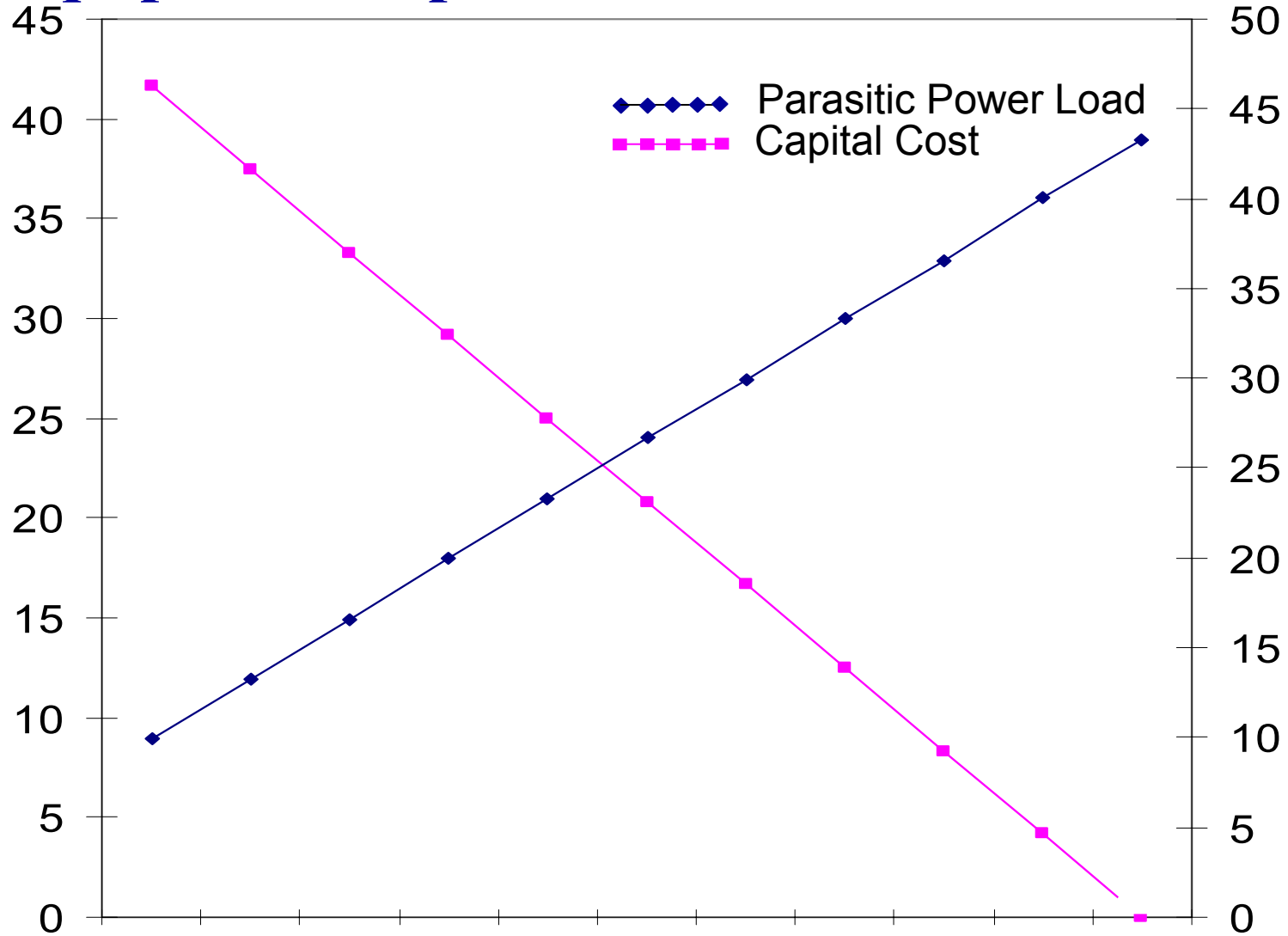
CO<sub>2</sub> Capture System Parasitic Load, MW

Basis: 400 MW (net) IGCC



# Equipment Capital Cost and Parasitic Load

CO<sub>2</sub> Capture System Capital Cost, \$MM



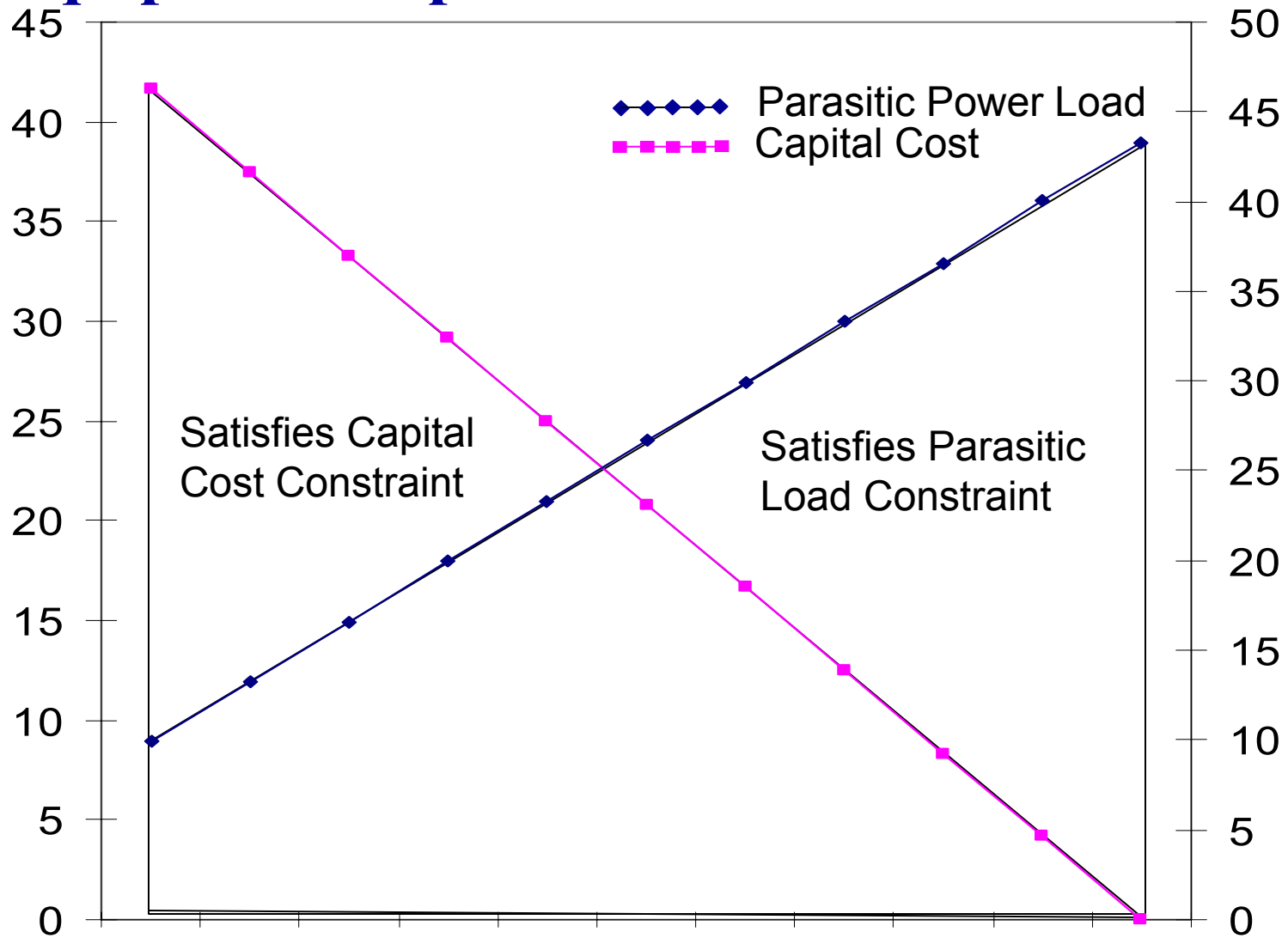
CO<sub>2</sub> Capture System Parasitic Load, MW

Basis: 400 MW (net) IGCC



# Equipment Capital Cost and Parasitic Load

CO<sub>2</sub> Capture System Capital Cost, \$MM



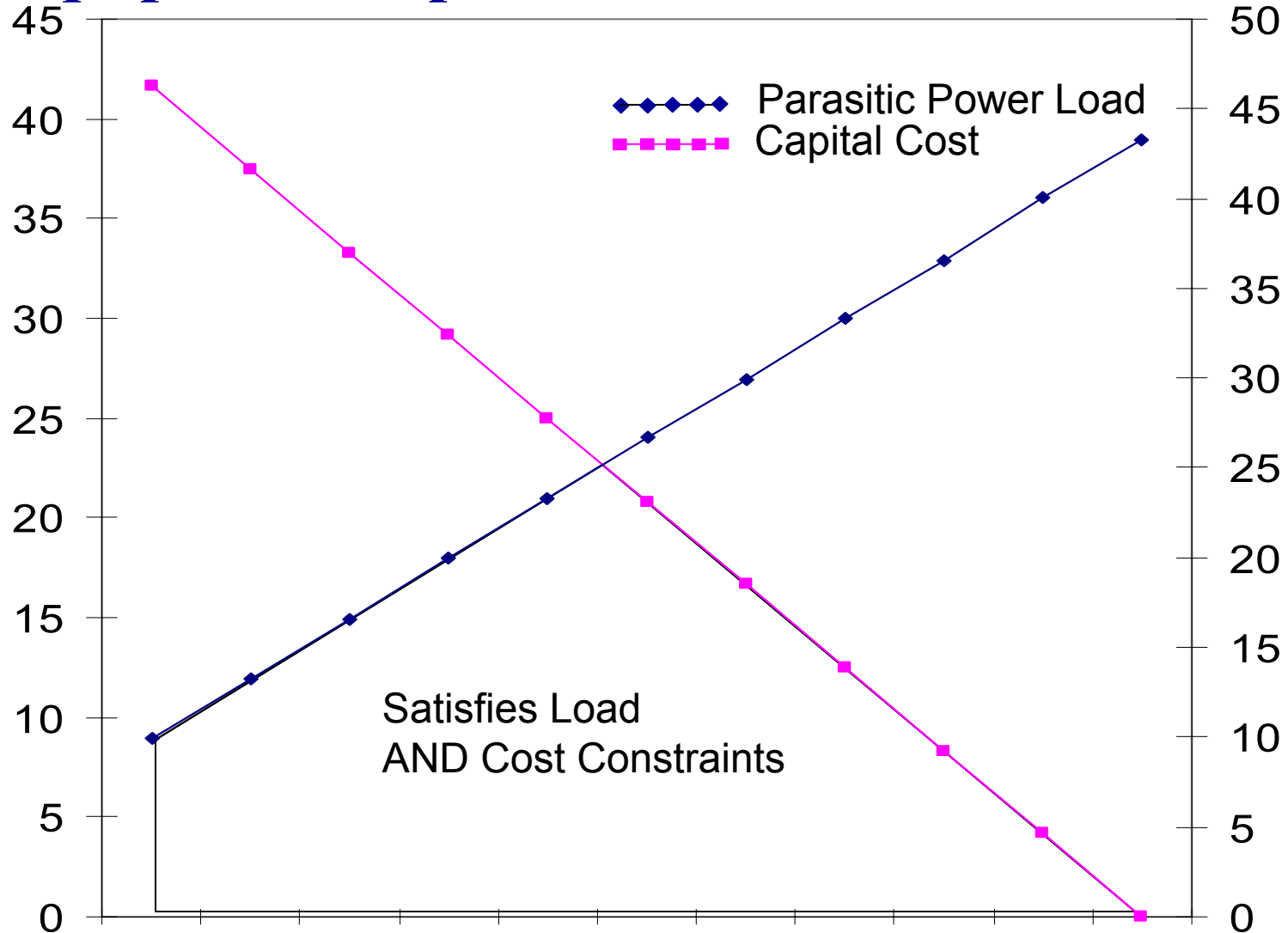
CO<sub>2</sub> Capture System Parasitic Load, MW

Basis: 400 MW (net) IGCC



# Equipment Capital Cost and Parasitic Load

CO<sub>2</sub> Capture System Capital Cost, \$MM



Satisfies Load  
AND Cost Constraints

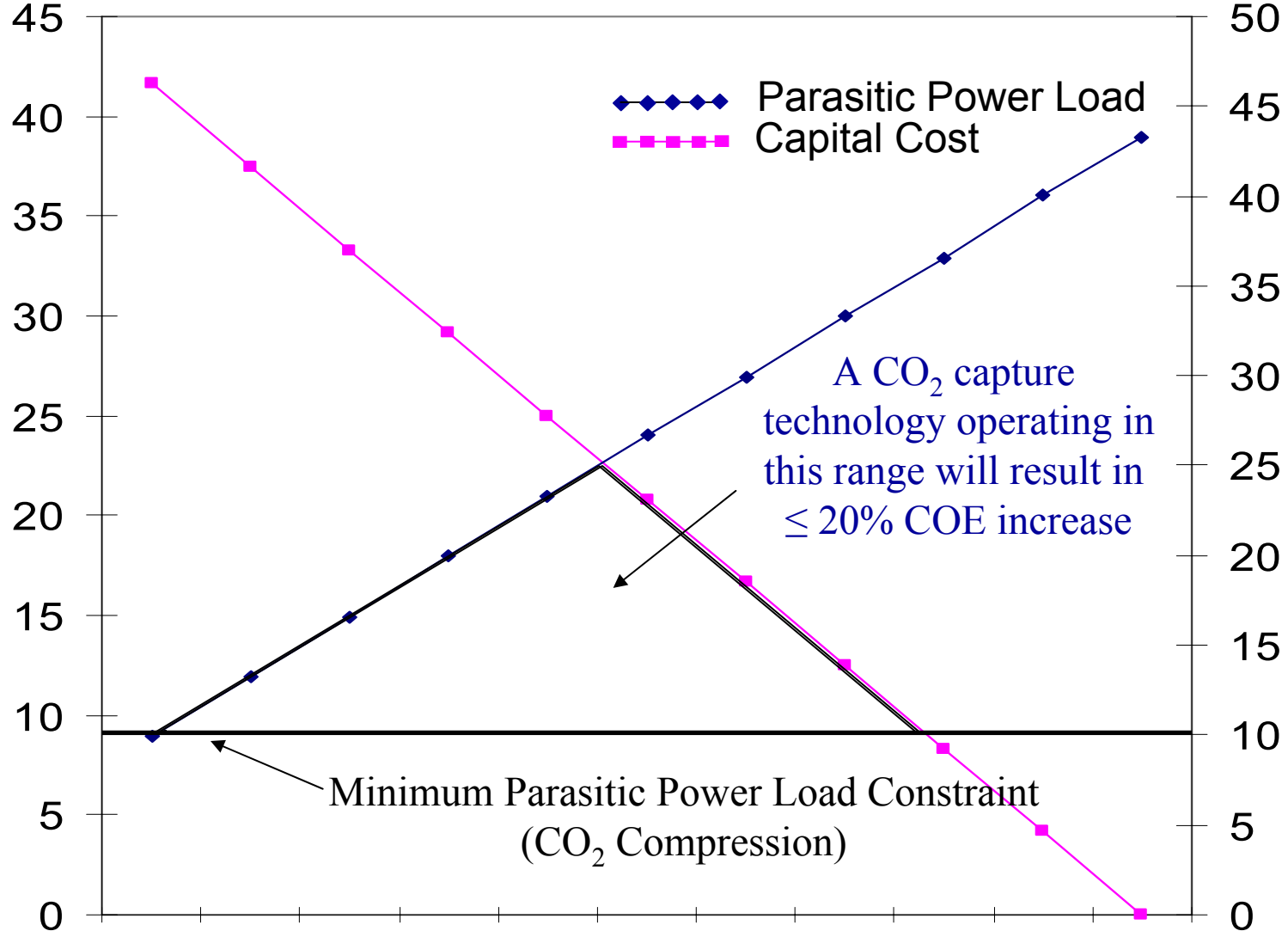
Basis: 400 MW (net) IGCC

CO<sub>2</sub> Capture System Parasitic Load, MW



# Equipment Capital Cost and Parasitic Load

CO<sub>2</sub> Capture System Capital Cost, \$MM



CO<sub>2</sub> Capture System Parasitic Load, MW

Basis: 400 MW (net) IGCC



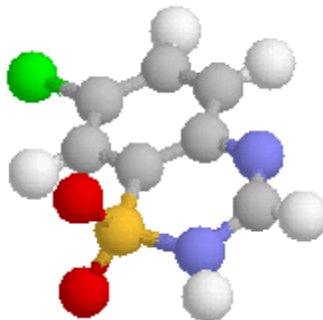
## Variables Affecting COE

So far, the variables we have considered are:

- CO<sub>2</sub> System Capital Cost (cost of equipment)
- Parasitic Power Load (increased coal consumption)

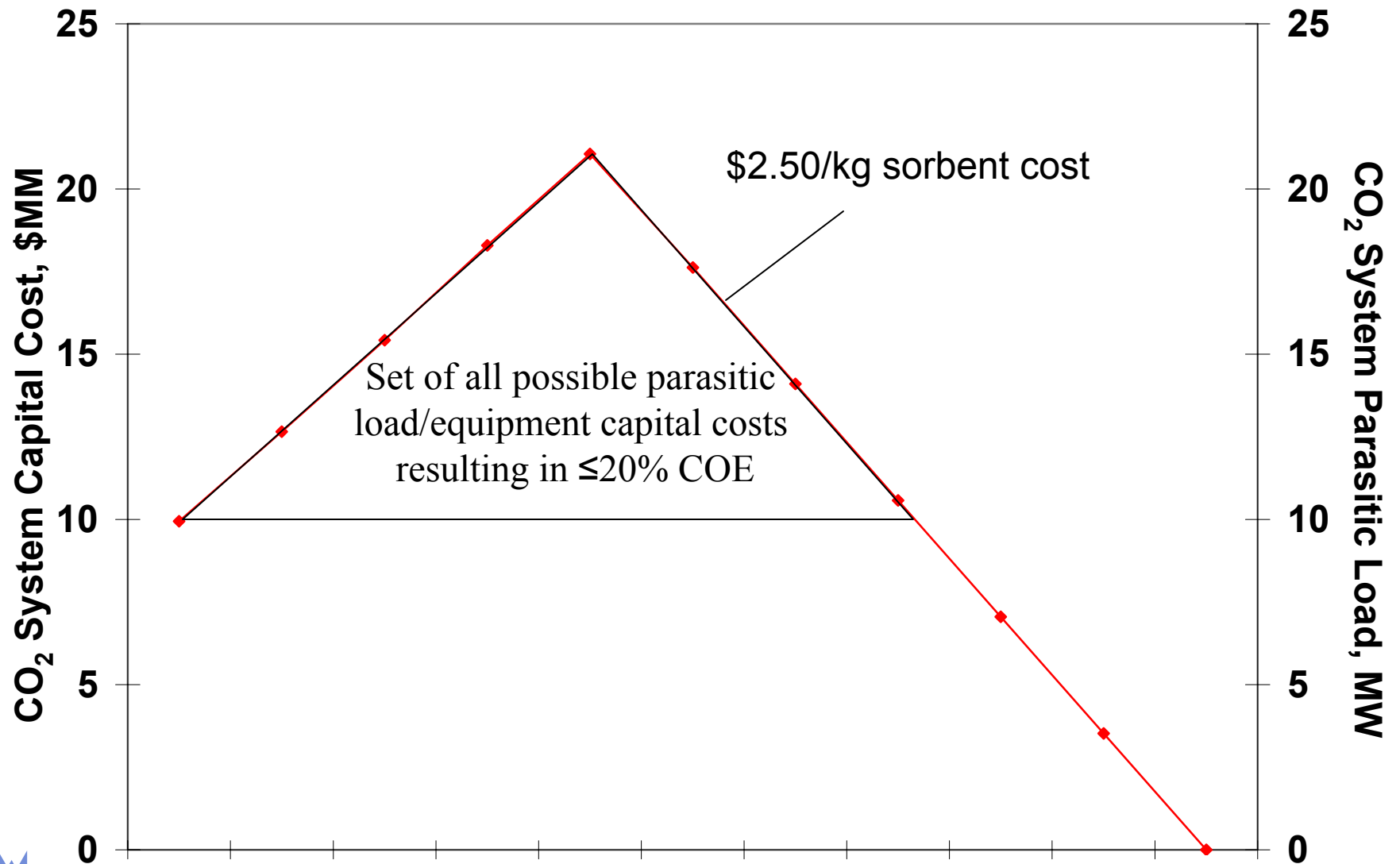
However, we haven't considered sorbent cost

- Assume enough sorbent for one hour cycle provided

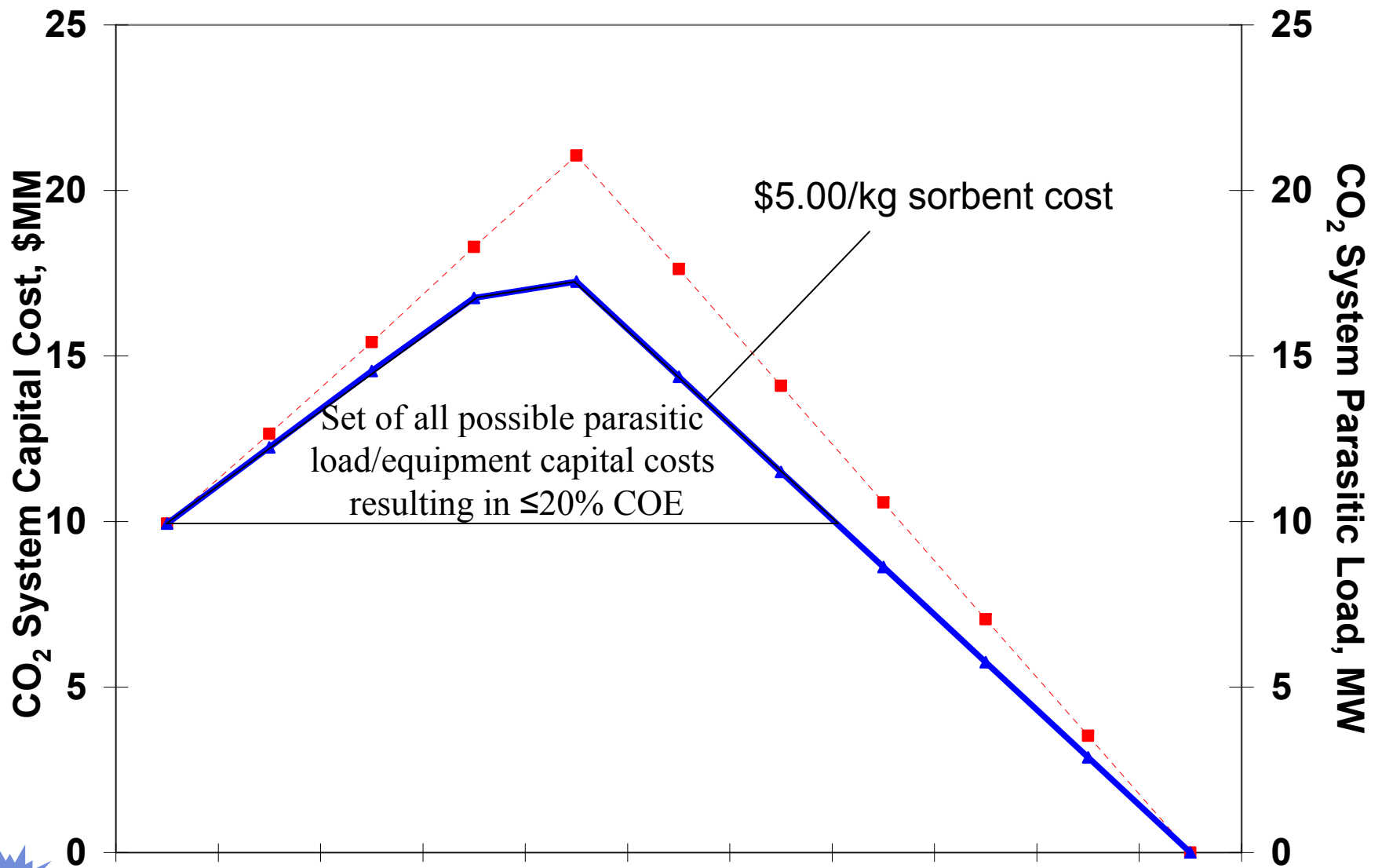




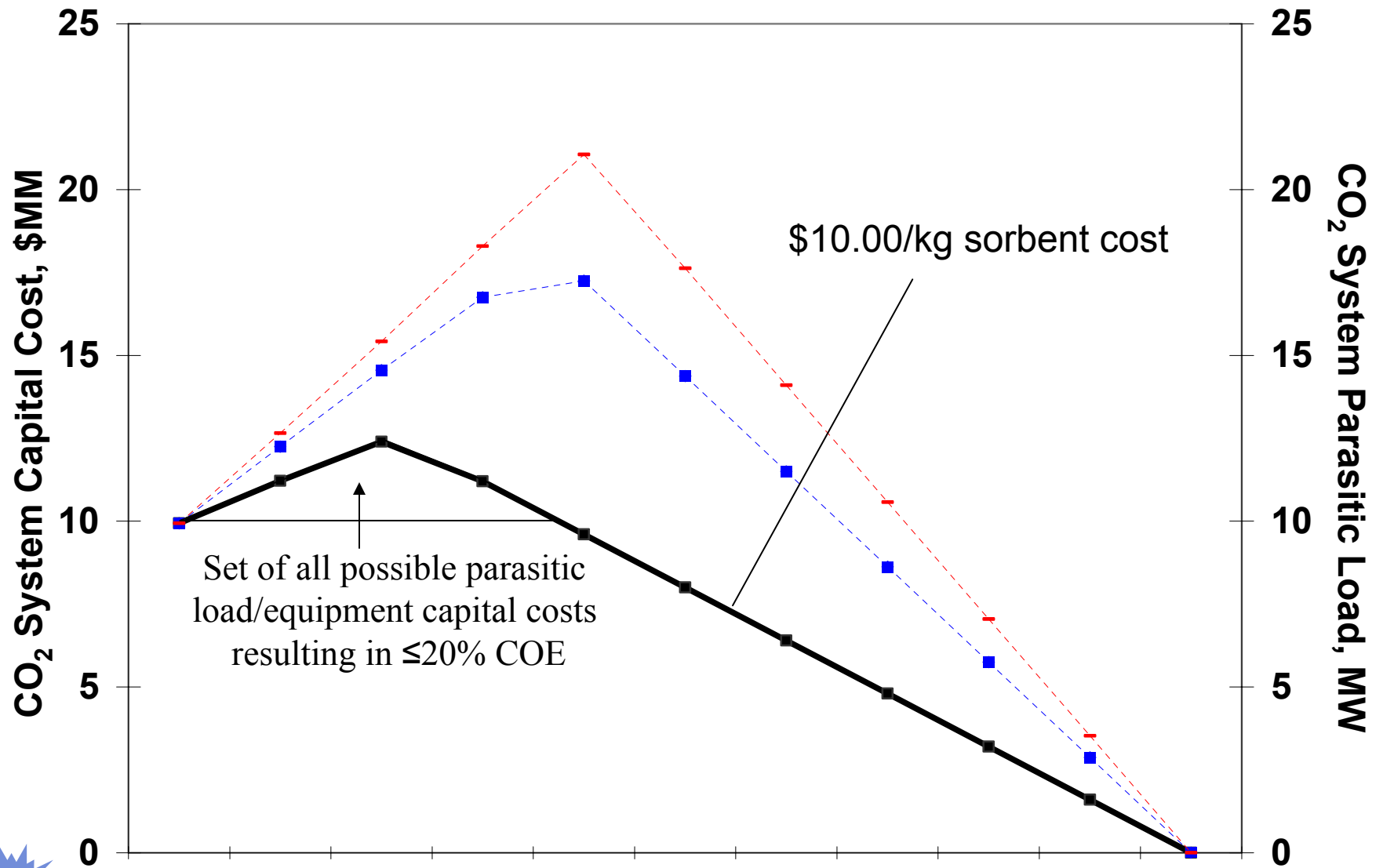
## 20% COE Increase



## 20% COE Increase



## 20% COE Increase



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## **20% COE Increase**

- **Define envelopes of operation for sorbent cost, equipment capital cost, parasitic power load**
- **Curves provide a way to quickly evaluate economic impact of CO<sub>2</sub> removal system**



## **Variables Affecting COE**

**Loss of sorbent capacity due to:**

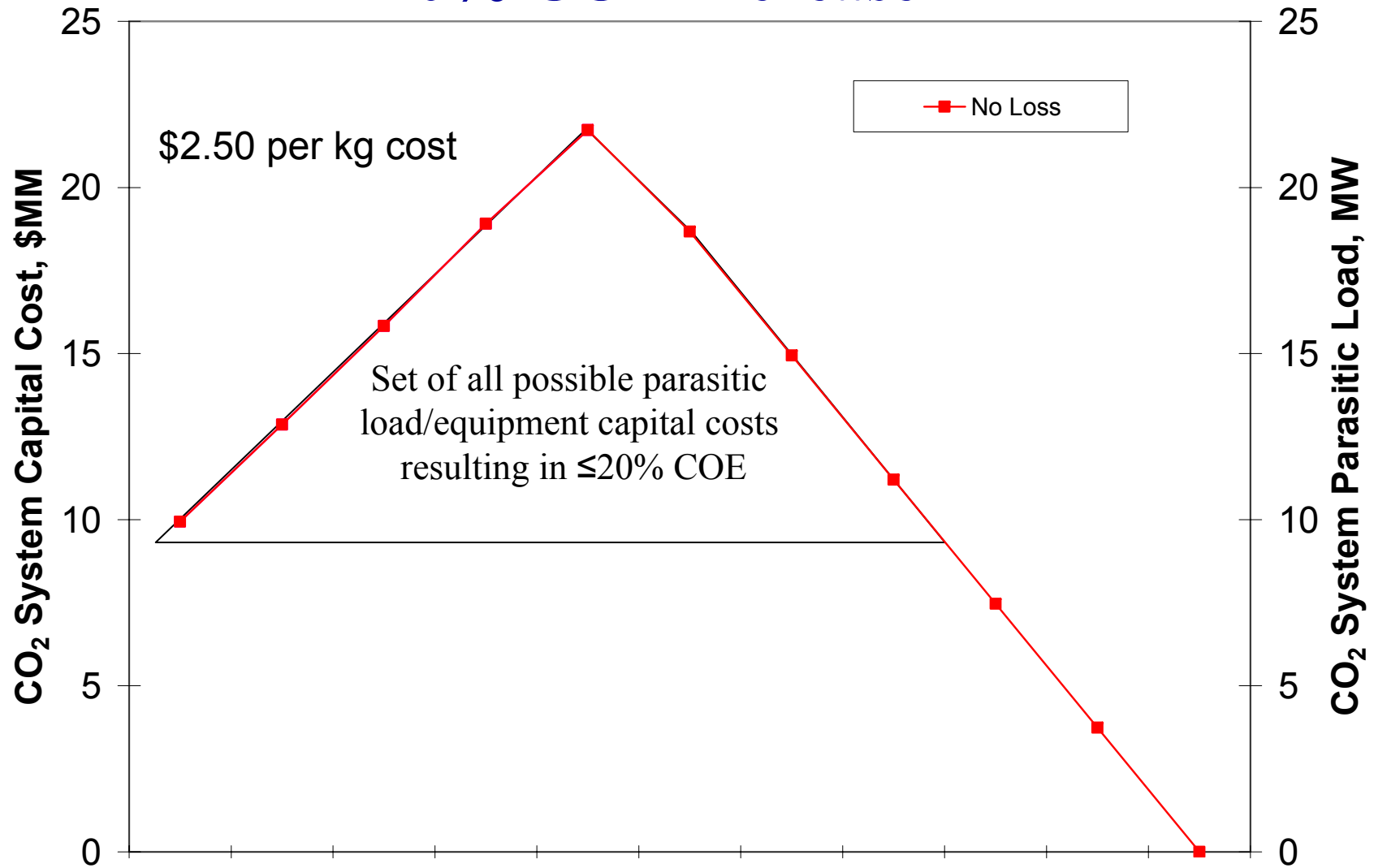
- Physical decomposition**
- Poisoning**

**...can be an additional operating expense**

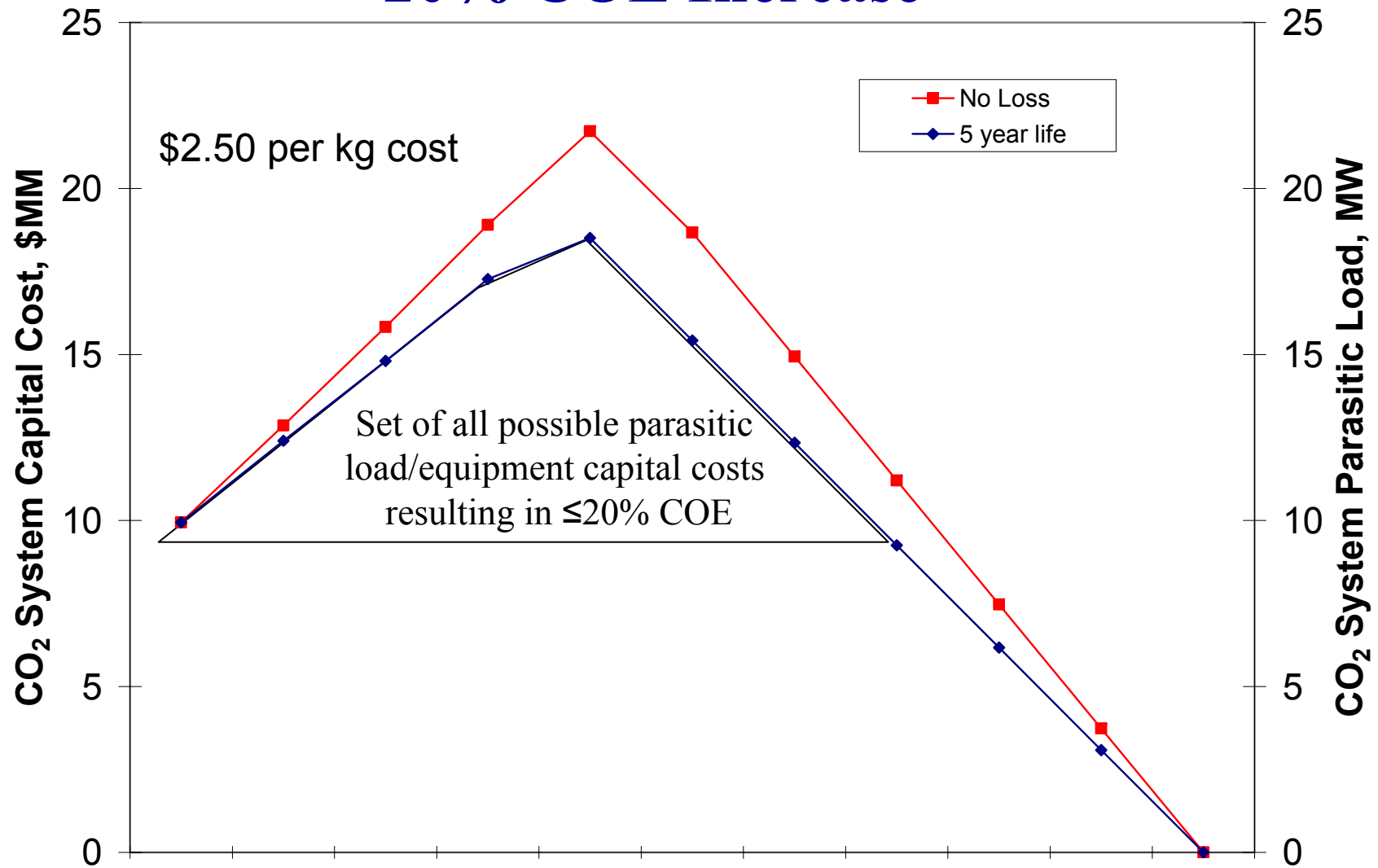
**How does this further constrain the system?**



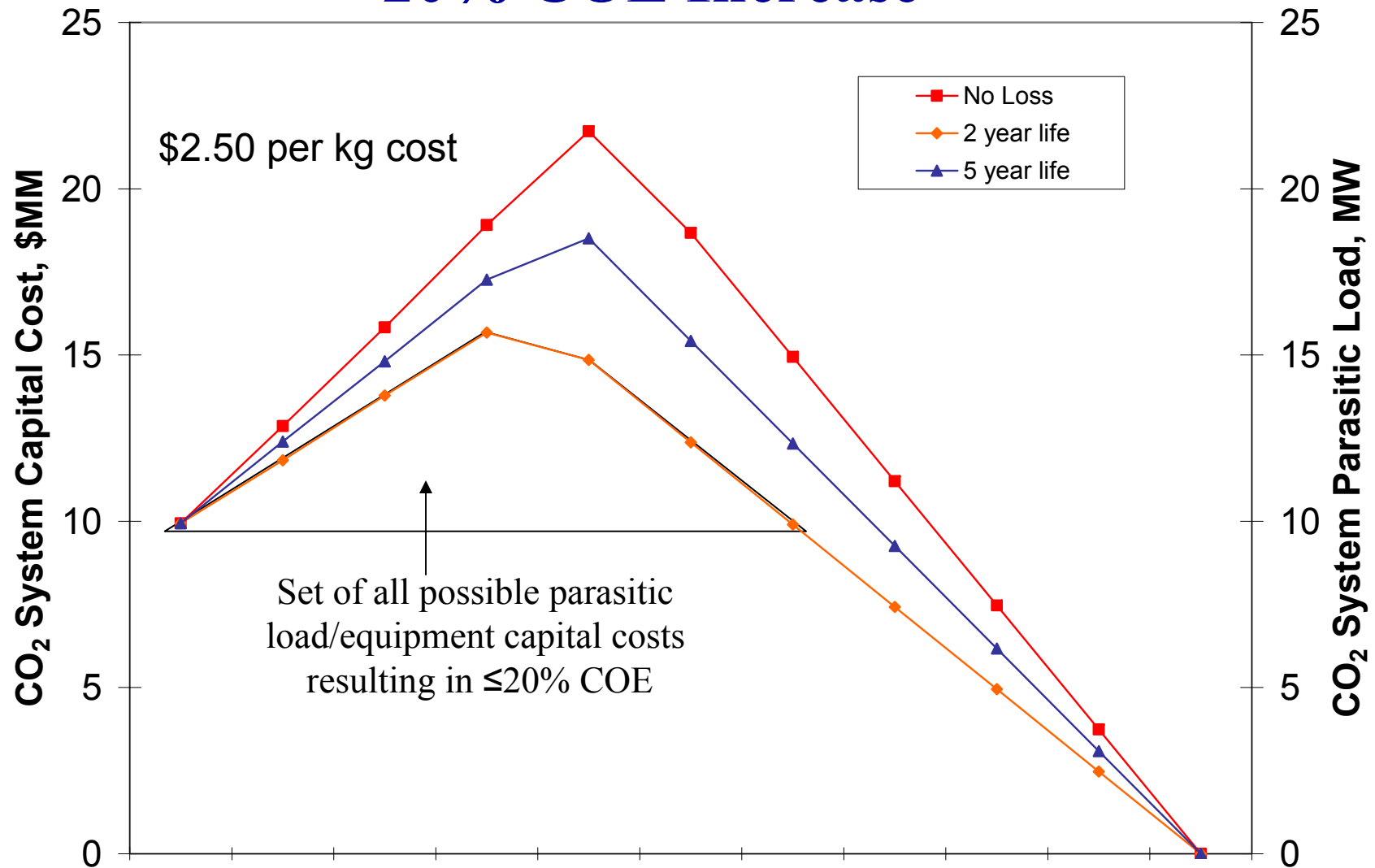
## 20% COE Increase



## 20% COE Increase

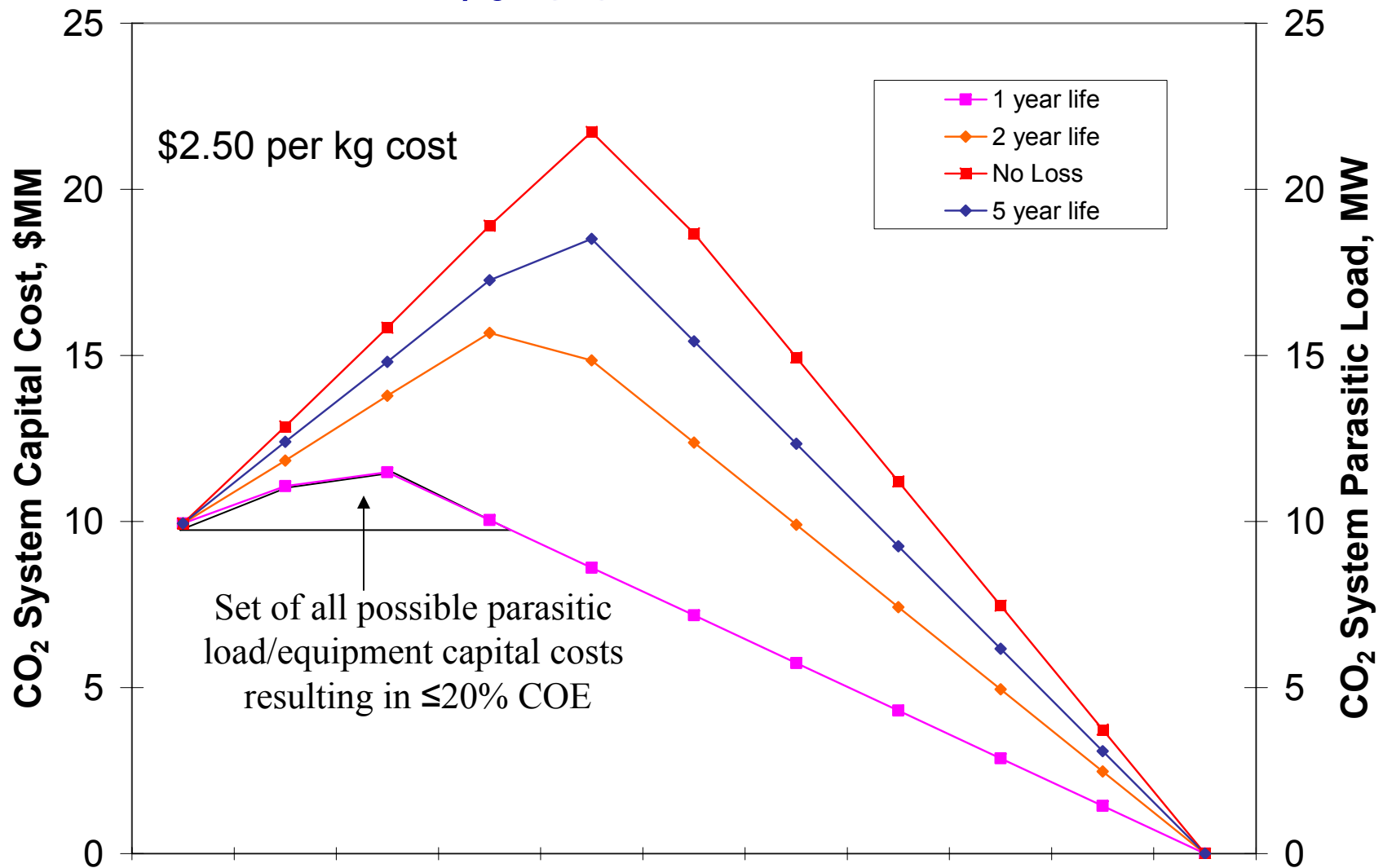


## 20% COE Increase





## 20% COE Increase



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## Summary

- Preliminary sorbent analysis provides targets for R&D
- Quantifies the need for inexpensive, durable sorbents
- Curves generated will allow for quick screening of CO<sub>2</sub> capture technologies



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## Future Work

- **Consider additional sorbent properties**
  - Heat capacity, absorption capacity, regeneration requirements, particle size
- **Propose possible system designs to accommodate sorbents**



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# Questions?

